

Table of Contents

CHAPTER 1. NUMBERS, STATISTICS AND ENVIRONMENTAL DECISION-MAKING

I. IN GENERAL

- § 1:1 Introduction
- § 1:2 Structure of the chapter

II. MATHEMATICAL AND SCIENTIFIC NOTATION (OR, UNDERSTANDING THE NUMBERS)

- § 1:3 Generally
- § 1:4 The decimal system, exponential notation and magnitude
- § 1:5 Logarithms
- § 1:6 Precision, accuracy, and significant digits

III. UNITS OF MEASUREMENT, CONVERSIONS, AND DIMENSIONAL ANALYSIS

- § 1:7 Generally
- § 1:8 Conversions
- § 1:9 Dimensional analysis and consistency

IV. STATISTICAL FUNDAMENTALS

- § 1:10 Generally
- § 1:11 Basic types of statistics
- § 1:12 Population and sample
- § 1:13 Variables and distributions
- § 1:14 Central tendencies (averages, means and medians)
- § 1:15 Measures of variability (range, variance, and standard deviations)
- § 1:16 The normal distribution
- § 1:17 Other distributions
- § 1:18 Estimation and confidence intervals
- § 1:19 Other interval estimation techniques
- § 1:20 Statistical significance
- § 1:21 Conditional probability and Bayesian statistics
- § 1:22 Graphs and tables
- § 1:23 Comparisons of data sets (ANOVA and t-Test)
- § 1:24 Trend (regression) analysis
- § 1:25 Control charts

V. WHY ENVIRONMENTAL STATISTICS ARE DIFFERENT (OR, THE LIMITATIONS)

- § 1:26 Generally
- § 1:27 Testing the distribution (Is it normal, lognormal, or neither?)
- § 1:28 Censored data (or, when measurements are not numbers)
- § 1:29 Extreme values

- § 1:30 Sample types
- § 1:31 Correlated data

VI. USING STATISTICS IN ENVIRONMENTAL DECISION-MAKING (OR, THE PURPOSE)

- § 1:32 Generally
- § 1:33 Characterization of soil quality & water quality/levels
- § 1:34 Design of sampling programs
- § 1:35 Evidence of contamination (or, the RCRA analyses)
- § 1:36 Risk assessment
- § 1:37 Developing standards and threshold levels
- § 1:38 Comparison to standards and thresholds levels
- § 1:39 Assessing the consistency and usability of large data sets
- § 1:40 Review of monitoring histories (or, monitoring optimization and monitored natural attenuation)

VII. HOW NOT TO LIE WITH STATISTICS (OR, ASSESSING IF THE DECISIONS ARE IMPORTANT AND VALUABLE, AND IF WE CAN BELIEVE THEM)

- § 1:41 Generally

CHAPTER 2. PHYSICS AND CHEMISTRY

I. IN GENERAL

- § 2:1 Introduction

II. BUILDING BLOCKS AND RULES OF MATTER

- § 2:2 Matter
- § 2:3 Substances
- § 2:4 Mixtures
- § 2:5 Atoms, elements, and isotopes
- § 2:6 Compounds and molecules
- § 2:7 Ions
- § 2:8 The mole
- § 2:9 Periodic table of the elements
- § 2:10 Conservation of matter

III. PHYSICAL PROPERTIES OF MATTER

- § 2:11 Definition of physical properties of matter
- § 2:12 Mass, weight, density, and specific gravity
- § 2:13 Physical states of matter—Definitions
- § 2:14 —Changes in the state of matter
- § 2:15 Vapor pressure
- § 2:16 Volatility
- § 2:17 Sublimation
- § 2:18 Absorption and adsorption
- § 2:19 Diffusion
- § 2:20 Solubility and partitioning

IV. CHEMISTRY

§ 2:21	Chemical properties of matter
§ 2:22	Bonding—Valence shells
§ 2:23	—Ionic and covalent bonding
§ 2:24	pH
§ 2:25	Chemical reactions
§ 2:26	Reactions classified by structure
§ 2:27	—Acid/base reactions
§ 2:28	— —Composition reactions
§ 2:29	— —Decomposition reactions
§ 2:30	— —Rearrangement reactions
§ 2:31	— —Single-displacement reactions
§ 2:32	— —Double-displacement reactions
§ 2:33	— —Hydrolysis
§ 2:34	— —Hydrogenation
§ 2:35	—Reactions classified by oxidation
§ 2:36	— —Rules for assigning oxidation states
§ 2:37	Chemical nomenclature
§ 2:38	—Organic nomenclature
§ 2:39	— —Hydrocarbons
§ 2:40	— —Hydrocarbon substituents
§ 2:41	— —Isomers
§ 2:42	— —Cyclic alkanes
§ 2:43	— —Naming conventions
§ 2:44	— —Naming alkane substituents
§ 2:45	— —Isomeric alkyl groups
§ 2:46	— —Alkenes and alkynes
§ 2:47	— —Alkene and alkyne substituents
§ 2:48	— — <i>cis</i> and <i>trans</i> isomers
§ 2:49	— —Aromatic hydrocarbons
§ 2:50	— —Functional groups
§ 2:51	Polymers
§ 2:52	Chemical nomenclature—Inorganic nomenclature—Elements
§ 2:53	— —Allotropes
§ 2:54	— —Homoatomic inorganic compounds
§ 2:55	— —Heteroatomic inorganic compounds
§ 2:56	— —Cations
§ 2:57	— —Anions
§ 2:58	— —Radicals
§ 2:59	— —Acids and bases
§ 2:60	Regulatory chemical nomenclature
§ 2:61	—Non-US Naming Systems
§ 2:62	—Nomenclature Corrections
§ 2:63	—Polymers
§ 2:64	—Nanosubstances
§ 2:65	—Isotopes
§ 2:66	—Nomenclature under amended TSCA
§ 2:67	Environmental chemistry
§ 2:68	—Petroleum hydrocarbons
§ 2:69	—Solvents
§ 2:70	—Phenols

- § 2:71 —Polynuclear aromatic hydrocarbons
- § 2:72 —Polychlorinated biphenyls (PCBs)
- § 2:73 —Per- and polyfluoroalkyl substances (PFAS)
- § 2:74 —Pesticides
- § 2:75 —Isoprenoids
- § 2:76 Isoprenoids—Acids and bases
- § 2:77 —Major ions
- § 2:78 —Metals
- § 2:79 —Cyanide
- § 2:80 Nanotechnology

V. NUCLEAR CHEMISTRY (NUCLEAR PHYSICS)

- § 2:81 Nuclear chemistry
- § 2:82 Types of radioactive decay
- § 2:83 Radionuclides and half-life
- § 2:84 Radon

CHAPTER 3. SAMPLING AND ANALYSIS

I. IN GENERAL

- § 3:1 Introduction

II. SAMPLE COLLECTION

- § 3:2 General
- § 3:3 Representative samples
- § 3:4 Sampling reproducibility
- § 3:5 Practical considerations regarding sampling
- § 3:6 Sampling locations
- § 3:7 Sampling plan
- § 3:8 Sampling techniques
- § 3:9 —Containers
- § 3:10 —Air
- § 3:11 — —Vapor density
- § 3:12 — —Units of measure
- § 3:13 —Ambient air
- § 3:14 —Stack air
- § 3:15 —Indoor air
- § 3:16 Sampling techniques—Soil vapor
- § 3:17 Sampling techniques—Water
- § 3:18 — —Surface water
- § 3:19 — —Groundwater
- § 3:20 — — —Well construction
- § 3:21 — — —Well purging
- § 3:22 — — —Sample collection
- § 3:23 —Soils
- § 3:24 — —Surface soils
- § 3:25 — —Subsurface soils
- § 3:26 —Sediments
- § 3:27 —Sample preservation/holding times
- § 3:28 — —Sample preservation

TABLE OF CONTENTS

§ 3:29	— — —Sample containers
§ 3:30	— — —Chemical preservatives
§ 3:31	— —Holding times
§ 3:32	—Sample shipment
§ 3:33	—Decontamination
§ 3:34	—Sampling documentation
§ 3:35	—Sampling quality control
§ 3:36	— —Blanks—Trip blanks
§ 3:37	— — —Rinse blanks
§ 3:38	— —Field Blanks
§ 3:39	— —Duplicates

III. CHEMICAL ANALYSES

§ 3:40	Generally
§ 3:41	Sample preparation
§ 3:42	—Organic compounds
§ 3:43	—Inorganic compounds
§ 3:44	Instrumental measurement
§ 3:45	—Chromatography
§ 3:46	— —Gas chromatography
§ 3:47	— — —Columns
§ 3:48	— — —Detectors
§ 3:49	— —High performance liquid chromatography
§ 3:50	— — —Columns
§ 3:51	— — —Detectors
§ 3:52	— —Ion chromatography
§ 3:53	— — —Columns
§ 3:54	— — —Detectors
§ 3:55	—Mass spectroscopy—In general
§ 3:56	—Mass spectrometry—Tandem Mass Spectrometry
§ 3:57	— —Compound Specific Isotope Analysis
§ 3:58	—Emission spectroscopy
§ 3:59	— —Flame emission spectroscopy
§ 3:60	— —Inductively coupled plasma
§ 3:61	—Atomic absorption spectroscopy—Flame
§ 3:62	— —Furnace or electrothermal
§ 3:63	—Infrared spectroscopy
§ 3:64	—X-ray fluorescence
§ 3:65	—Meters
§ 3:66	Data reduction—Calibration
§ 3:67	— —External standard calibration
§ 3:68	— —Internal standard calibration
§ 3:69	—Sample concentration calculations
§ 3:70	— —External calibration
§ 3:71	— —Internal calibration
§ 3:72	Analytical methods
§ 3:73	—EPA methods—Contract laboratory program
§ 3:74	— —SW 846
§ 3:75	— —Water
§ 3:76	— —Air
§ 3:77	—National Institute for Occupational Safety and Health

- § 3:78 —Standard methods
- § 3:79 —Association of official analytical chemists
- § 3:80 —Immunoassay
- § 3:81 —Custom methods
- § 3:82 Methods applicable to classes of compounds
- § 3:83 —Organics—Volatiles
- § 3:84 — —Semivolatiles
- § 3:85 — —Pesticides/PCBs
- § 3:86 — —Herbicides
- § 3:87 — —Polycyclic aromatic hydrocarbons (PAHs) and polynuclear aromatic hydrocarbons (PNAs)
- § 3:88 — —Petroleum hydrocarbons
- § 3:89 — — —Total petroleum hydrocarbons
- § 3:90 — — —Specific petroleum fractions
- § 3:91 —Inorganics—Metals
- § 3:92 — —Perchlorate

IV. QUALITY ASSURANCE/QUALITY CONTROL

- § 3:93 Generally
- § 3:94 Chain of custody
- § 3:95 Detection and quantitation limits
- § 3:96 —Detection limits
- § 3:97 — —Instrument detection limit
- § 3:98 — —Method detection limit
- § 3:99 — —Limit of detection
- § 3:100 —Quantitation limits
- § 3:101 — —Lower limit of quantitation
- § 3:102 — —Practical quantitation limit
- § 3:103 — —Limit of quantitation
- § 3:104 —Matrix interference
- § 3:105 Precision and accuracy
- § 3:106 Calibration
- § 3:107 —Continuing calibration checks
- § 3:108 —Laboratory control samples
- § 3:109 —Tuning
- § 3:110 Quality control samples
- § 3:111 —Blanks
- § 3:112 — —Calibration blank
- § 3:113 — —Method blank
- § 3:114 — —Storage blanks
- § 3:115 — —Reagent blanks
- § 3:116 —Spikes
- § 3:117 — —Blank spikes
- § 3:118 — —Matrix spikes
- § 3:119 — —Post-digestion/post-extraction spikes
- § 3:120 —Duplicates
- § 3:121 — —Laboratory duplicates
- § 3:122 — —Injection duplicates
- § 3:123 — —Matrix spike duplicates
- § 3:124 — —Relative percent difference

V. DATA REPORTING AND VALIDATION

- § 3:125 Data reporting
- § 3:126 Laboratory qualifiers
- § 3:127 Laboratory data qualifiers—Qualifiers for organics analyses
- § 3:128 Laboratory qualifiers—Qualifiers for inorganics analyses
- § 3:129 Data validation

CHAPTER 4. HEALTH RISK ASSESSMENT

I. IN GENERAL

- § 4:1 Introduction

II. HUMAN HEALTH HAZARD IDENTIFICATION

- § 4:2 Introduction
- § 4:3 Toxicity to humans
- § 4:4 Evaluation of the weight of evidence
- § 4:5 Epidemiologic studies
- § 4:6 Laboratory studies
- § 4:7 The WoE analysis

III. DOSE-RESPONSE ASSESSMENT

- § 4:8 Introduction
- § 4:9 Carcinogens
- § 4:10 Noncarcinogens

IV. EXPOSURE ASSESSMENT

- § 4:11 Introduction
- § 4:12 Exposure routes and pathways
- § 4:13 Exposure durations and timing
- § 4:14 Dose estimation
- § 4:15 Biomonitoring

V. RISK CHARACTERIZATION

- § 4:16 Introduction
- § 4:17 Numerical estimates of risk
- § 4:18 Risk-Based target levels
- § 4:19 Uncertainty and variability
- § 4:20 Improving risk characterization
- § 4:21 Aggregate and Cumulative Risk Assessment
- § 4:22 Environmental justice and cumulative risk
- § 4:23 Toxicogenomics

VI. INTRODUCTION TO PROBABILISTIC RISK ASSESSMENT

- § 4:24 Introduction to Probabilistic Risk Assessment
- § 4:25 The deterministic approach
- § 4:26 The probabilistic approach
- § 4:27 Comparison of deterministic and probabilistic approaches

VII. ECOLOGICAL RISK ASSESSMENT

- § 4:28 Drivers and applications
- § 4:29 Definition and structure—What is ERA?
- § 4:30 —Types of ERA
- § 4:31 —ERA and human health risk assessment
- § 4:32 The ERA Process
- § 4:33 —Problem formulation
- § 4:34 The ERA process—Analysis
- § 4:35 — —Effects assessment
- § 4:36 — —Exposure assessment
- § 4:37 —Risk characterization
- § 4:38 Ecological risk management and communication

CHAPTER 5. GROUNDWATER

I. GROUNDWATER CONCEPTS

- § 5:1 Hydrologic cycle
- § 5:2 Occurrence of groundwater

II. GROUNDWATER FLOW

- § 5:3 Hydraulic head and gradient
- § 5:4 Porosity, hydraulic conductivity, permeability, and transmissivity
- § 5:5 Darcy's Law
- § 5:6 Flow nets
- § 5:7 Flow in fractures
- § 5:8 Steady state and transient conditions
- § 5:9 Aquifer pumping tests
- § 5:10 —Unconfined aquifer
- § 5:11 —Confined aquifer
- § 5:12 —Single well tests

III. CONTAMINANT MIGRATION

- § 5:13 Contaminant migration—Generally
- § 5:14 Aqueous phase
- § 5:15 —Source term
- § 5:16 —Advection
- § 5:17 —Dispersion
- § 5:18 —Diffusion
- § 5:19 —Retardation
- § 5:20 —Degradation and radioactive decay
- § 5:21 —Dual porosity
- § 5:22 —Contaminant plumes
- § 5:23 Non-aqueous phase liquids
- § 5:24 —LNAPLs or floaters
- § 5:25 —DNAPLs or sinkers
- § 5:26 Recalcitrant contaminants
- § 5:27 Emerging contaminants
- § 5:28 Heat transport

IV. GROUNDWATER ANALYSIS AND MODELING

- § 5:29 Analysis and modeling—Generally
- § 5:30 Conceptual site model
- § 5:31 Analytical solutions
- § 5:32 Numerical models—Generally
- § 5:33 —Applications for decision making
- § 5:34 —Complexity of subsurface
- § 5:35 —Moving from simple to complex models
- § 5:36 —Uncertainty effects on decision making
- § 5:37 —Interaction of groundwater and surface water

V. GROUNDWATER INVESTIGATIONS

- § 5:38 Initial data review
- § 5:39 Program planning
- § 5:40 Drilling
- § 5:41 —Auger
- § 5:42 —Cable tool
- § 5:43 —Air rotary
- § 5:44 —Mud rotary
- § 5:45 —Dual rotary
- § 5:46 —Sonic
- § 5:47 —Direct push technology
- § 5:48 —Horizontal directional drilling
- § 5:49 Monitoring well installation
- § 5:50 Groundwater sampling

VI. GROUNDWATER REMEDIATION

- § 5:51 Limitations of pump and treat
- § 5:52 Source control
- § 5:53 —Removal—Excavation
- § 5:54 — —Free product recovery
- § 5:55 — —Soil vapor extraction
- § 5:56 —Containment—Caps
- § 5:57 — —Barriers
- § 5:58 —Treatment
- § 5:59 Dissolved plume control and remediation—Hydraulic control, pump and treat
- § 5:60 —Enhanced remediation methods
- § 5:61 —*In situ* remediation methods
- § 5:62 Mass flux and mass discharge
- § 5:63 Emerging remediation approaches

VII. GROUNDWATER/SURFACE WATER INTERACTION

- § 5:64 Groundwater/surface water interaction—Generally

CHAPTER 6. SURFACE WATER QUALITY AND WASTEWATER TREATMENT

I. SURFACE WATER QUALITY AND AQUATIC ECOSYSTEMS

- § 6:1 Progress in water quality—Accomplishments to date and remaining work

- § 6:2 Principal sources of pollution—Leading sources of water quality impairment
- § 6:3 —Total Maximum Daily Load (TMDL) Program
- § 6:4 General characteristics of aquatic ecosystems
- § 6:5 —Food webs
- § 6:6 —Energy and material transfer
- § 6:7 —Population dynamics

II. POLLUTANT CATEGORIES AND EFFECTS ON SURFACE WATERS

- § 6:8 Generally
- § 6:9 Pollution of surface waters
- § 6:10 —Organic enrichment/oxygen depletion
- § 6:11 —Oxygen depletion—Biochemical oxygen demand (BOD)
- § 6:12 — —Chemical oxygen demand (COD)
- § 6:13 —Eutrophication
- § 6:14 —Temperature effects
- § 6:15 —Toxicity, mutagenic and metabolic effects
- § 6:16 —Pathogens
- § 6:17 —Siltation/turbidity
- § 6:18 —Salinity
- § 6:19 Classification and measurement of pollutants
- § 6:20 —Conventional pollutants
- § 6:21 — —Biochemical oxygen demand (BOD)
- § 6:22 — —Fecal coliform
- § 6:23 — —Total suspended solids (TSS)
- § 6:24 — —Oil and grease (O & G)
- § 6:25 — —pH
- § 6:26 —Other pollutants—Nitrogen
- § 6:27 — —Phosphorus
- § 6:28 — —Cyanide
- § 6:29 — —Surfactants
- § 6:30 — —Chemical Oxygen Demand (COD)
- § 6:31 — —Total Organic Carbon (TOC)
- § 6:32 — —Volatile Suspended Solids (VSS)
- § 6:33 — —Total Dissolved Solids (TDS)
- § 6:34 — —Total solids
- § 6:35 — —Settleable solids
- § 6:36 — —Pathogens
- § 6:37 — —Turbidity
- § 6:38 — —Odor
- § 6:39 — —Radionuclides
- § 6:40 — —Heavy metals (total and dissolved)
- § 6:41 — —Pesticides
- § 6:42 — —Polynuclear aromatic hydrocarbons (PAHs)
- § 6:43 — —Polychlorinated biphenyls (PCBs)
- § 6:44 —Priority pollutants
- § 6:45 —Per- and Polyfluoroalkyl Substances (PFAS)
- § 6:46 —6PPD
- § 6:47 Pharmaceuticals and personal care products

III. WASTEWATER TREATMENT UNIT OPERATIONS

- § 6:48 Generally

TABLE OF CONTENTS

§ 6:49	Pre- and primary treatment technologies—Screening and grit removal
§ 6:50	—Equalization
§ 6:51	—Primary clarification
§ 6:52	—Neutralization
§ 6:53	—Oil removal
§ 6:54	—Flotation
§ 6:55	Biological treatment technologies
§ 6:56	—Activated sludge treatment
§ 6:57	— —Organic loading
§ 6:58	— —Oxygen requirements
§ 6:59	— —Nutrient requirements
§ 6:60	— —Effect of temperature
§ 6:61	— —Effect of pH
§ 6:62	— —Effect of toxicity
§ 6:63	—Other suspended growth biological treatment systems
§ 6:64	—Attached growth systems
§ 6:65	—Anaerobic biological treatment systems
§ 6:66	Miscellaneous biological treatment processes—Membrane biological reactors (MBR)
§ 6:67	—Moving bed biological reactors (MBBR)
§ 6:68	Physical-chemical treatment systems—Activated carbon adsorption
§ 6:69	—Ion exchange systems
§ 6:70	— —Cation exchange
§ 6:71	— —Anion exchange
§ 6:72	—Stripping—Air stripping
§ 6:73	— — —VOC removal
§ 6:74	— — —Ammonia removal
§ 6:75	— —Steam stripping
§ 6:76	—Coagulation, flocculation and sedimentation
§ 6:77	—Heavy metals removal
§ 6:78	—Chemical oxidation and reduction
§ 6:79	—Hydrothermal processes
§ 6:80	—Membrane technologies
§ 6:81	— —Reverse osmosis
§ 6:82	— —Electrodialysis
§ 6:83	— —Nanofiltration, ultrafiltration, and microfiltration
§ 6:84	—Filtration
§ 6:85	—Disinfection
§ 6:86	Nutrient removal—Phosphorus removal
§ 6:87	— —Chemical precipitation
§ 6:88	— —Biological removal
§ 6:89	— —Nitrogen removal
§ 6:90	— —Physical/chemical processes
§ 6:91	— —Biological processes
§ 6:92	— —Nitrification
§ 6:93	— —Denitrification
§ 6:94	Sludge handling and disposal
§ 6:95	—Types of sludges
§ 6:96	—Sludge thickening
§ 6:97	—Sludge dewatering
§ 6:98	—Sludge disposal

IV. CHARACTERIZATION AND TREATMENT OF SELECTED INDUSTRIAL WASTEWATERS

- § 6:99 Produced and reject wastewaters from shale oil operations
- § 6:100 Shale oil wastewater characteristics
- § 6:101 Treatment technologies for shale oil wastewater
- § 6:102 Specific treatment technologies for shale oil wastewater

CHAPTER 7. SOLID WASTE AND CONTAMINATED SOIL

I. INTRODUCTION

- § 7:1 Types of contaminated solids
- § 7:2 Regulatory basis
- § 7:3 Mechanisms of contamination
- § 7:4 —Organic contamination
- § 7:5 —Inorganic contamination
- § 7:6 Impacts and Concerns
- § 7:7 —Human Health Concerns
- § 7:8 —Ecological concerns
- § 7:9 Treatment of contaminated solids—Summary Overview
- § 7:10 —Treatment goals
- § 7:11 —Categories of technologies
- § 7:12 — —Thermal Technologies
- § 7:13 — —Biological technologies
- § 7:14 — —Chemical processes
- § 7:15 — — —Oxidation
- § 7:16 — — —Reduction
- § 7:17 — — —Stabilization
- § 7:18 — — —Fixation
- § 7:19 — —Physical treatment
- § 7:20 — — —Isolation
- § 7:21 — — —Extraction

II. THERMAL TREATMENT

- § 7:22 Overview
- § 7:23 Combustion
- § 7:24 —Incinerators
- § 7:25 —Waste burning in industrial processes
- § 7:26 — —Cement kilns
- § 7:27 — —Boilers
- § 7:28 — —Municipal waste incinerators
- § 7:29 —Applicability of process to contaminants
- § 7:30 —Applicability of process to types of solids
- § 7:31 Vitrification
- § 7:32 —Applicability of process to contaminants
- § 7:33 —Ex situ versus in situ
- § 7:34 —Applicability of process to types of solids
- § 7:35 Desorption
- § 7:36 —Low temperature
- § 7:37 —High temperature

TABLE OF CONTENTS

- § 7:38 —Thermochemical stabilization
- § 7:39 —Chemical heating (quicklime)
- § 7:40 —Applicability of process to contaminants
- § 7:41 —Ex Situ versus in situ
- § 7:42 —Applicability of process to types of solids

III. BIOLOGICAL TREATMENT

- § 7:43 Overview
- § 7:44 Microbial processes
 - § 7:45 —Oxygen utilization
 - § 7:46 —Nitrate reduction
 - § 7:47 —Manganese reduction
 - § 7:48 —Iron reduction
 - § 7:49 —Reductive dechlorination
 - § 7:50 —Sulfate reduction
 - § 7:51 —Methanogenesis and fermentation
 - § 7:52 —LNAPL attenuation
- § 7:53 Mycological processes
- § 7:54 Phytological Processes

IV. CHEMICAL TREATMENT METHODS

- § 7:55 Overview
- § 7:56 Chemical oxidation
 - § 7:57 —Available oxidants
 - § 7:58 —Use of oxidants
 - § 7:59 —Application of oxidants
 - § 7:60 —Health and safety
- § 7:61 Chemical reduction
 - § 7:62 —Available reductants
 - § 7:63 —Use of reductants
 - § 7:64 —Application of reductants
 - § 7:65 —Health and safety
- § 7:66 Stabilization
 - § 7:67 —Stabilization Techniques
 - § 7:68 —Additives
- § 7:69 Fixation

V. PHYSICAL TREATMENT METHODS

- § 7:70 Overview
- § 7:71 Isolation
 - § 7:72 —Caps and covers
 - § 7:73 —Barriers
 - § 7:74 — —Sheet pilings
 - § 7:75 — —Slurry walls
 - § 7:76 — —Vapor barrier
- § 7:77 Soil washing and soil flushing
 - § 7:78 —Soil washing
 - § 7:79 —Beneficiation
 - § 7:80 —Soil flushing
- § 7:81 —Applicability of processes to contaminants

- § 7:82 —Ex Situ versus in situ
- § 7:83 —Applicability of processes to types of solids
- § 7:84 Solvent extraction
- § 7:85 —Applicability of process to contaminants
- § 7:86 —Applicability of process to types of solids
- § 7:87 Vapor extraction
- § 7:88 —Low vacuum
- § 7:89 —High vacuum/dual phase extraction
- § 7:90 —Soil shredding
- § 7:91 —Applicability of process to contaminants
- § 7:92 —Applicability of processes to types of solids
- § 7:93 —Ex Situ versus in situ

CHAPTER 8. AIR

I. AIR POLLUTION TERMINOLOGY

- § 8:1 Generally
- § 8:2 Air pollution
- § 8:3 Forms of air pollution
- § 8:4 —Particulate matter
- § 8:5 — —Units used
- § 8:6 —Gases and vapors
- § 8:7 — —Units used
- § 8:8 Types of regulated pollutants
- § 8:9 —Criteria pollutants
- § 8:10 —Secondary pollutants
- § 8:11 —Hazardous air pollutants
- § 8:12 Hazardous air pollutants special topic: mercury
- § 8:13 Types of regulated pollutants—Regulated substances/ Extremely hazardous substances
- § 8:14 —Ozone-depleting chemicals
- § 8:15 —Greenhouse gases
- § 8:16 Sources of air pollution

II. AIR QUALITY MONITORING AND MODELING

- § 8:17 Modeling and monitoring—Generally
- § 8:18 Quantifying source emissions
- § 8:19 —Engineering calculations
- § 8:20 — —Published emission factors
- § 8:21 — —Vendor specifications and guarantees
- § 8:22 — —Emission modeling
- § 8:23 — —Material balances
- § 8:24 — —Design specifications of control equipment
- § 8:25 —Direct pollutant measurement
- § 8:26 — —Manual sampling
- § 8:27 — —Continuous instrumental monitoring
- § 8:28 —Parametric monitoring
- § 8:29 Estimating source emissions—Leak Detection and Repair
- § 8:30 —Emerging/unconventional methods
- § 8:31 Ambient air monitoring

TABLE OF CONTENTS

- § 8:32 Compliance testing and monitoring
- § 8:33 Atmospheric dispersion modeling

III. AIR POLLUTION CONTROL

- § 8:34 Air pollution control—Generally
- § 8:35 Particulate matter
 - § 8:36 —Cyclones
 - § 8:37 —Fabric filters
 - § 8:38 —Electrostatic precipitators
 - § 8:39 —Wet scrubbers
- § 8:40 Gases and vapors
 - § 8:41 —Thermal Oxidation
 - § 8:42 —Adsorption
 - § 8:43 —Absorption
 - § 8:44 —Selective Catalytic Reduction
 - § 8:45 —Condensation
- § 8:46 Greenhouse gases

CHAPTER 9. WETLANDS

I. WETLANDS JURISDICTION & DEFINITIONS

- § 9:1 Wetlands jurisdiction
- § 9:2 —Special aquatic sites
- § 9:3 Federal wetlands definition—Overview
- § 9:4 —State and local wetlands definitions

II. WETLAND OCCURRENCES

- § 9:5 Transitional habitats
- § 9:6 Landscape position
 - § 9:7 —Tidally-influenced wetlands
 - § 9:8 —Floodplain areas
 - § 9:9 —Depressional areas
 - § 9:10 —Seepage areas

III. TYPES OF WETLANDS

- § 9:11 Generally
- § 9:12 —Wetland classification
- § 9:13 General characteristics of common wetland types
- § 9:14 Forested wetlands
 - § 9:15 —Coniferous forested wetlands
 - § 9:16 —Broadleaf forested wetlands
- § 9:17 Scrub-shrub wetlands
- § 9:18 Herbaceous wetlands
 - § 9:19 —Salt marsh
 - § 9:20 —Freshwater marsh
- § 9:21 Other wetlands

IV. WETLANDS IDENTIFICATION AND DELINEATION STANDARDS AND CRITERIA

- § 9:22 Wetlands standard

- § 9:23 Wetlands identification and delineation criteria
- § 9:24 —Wetlands hydrology
- § 9:25 — —Standard
- § 9:26 — —Indicators
- § 9:27 — —Application
- § 9:28 —Hydric soil
- § 9:29 — —Standard
- § 9:30 — —Wetland Indicators
- § 9:31 — —Application
- § 9:32 —Hydrophytic vegetation
- § 9:33 — —Standard
- § 9:34 — —Indicators
- § 9:35 — —Application
- § 9:36 Other considerations
- § 9:37 —Normal environmental conditions
- § 9:38 —Normal circumstances
- § 9:39 Standard for wetlands conclusion

V. WETLANDS DELINEATION PROCEDURES

- § 9:40 Generally
- § 9:41 Routine procedures
- § 9:42 Comprehensive procedures
- § 9:43 Atypical situation procedures
- § 9:44 Problem area procedures

VI. WETLANDS FUNCTIONS & VALUES

- § 9:45 Generally
- § 9:46 Functions and values distinguished
- § 9:47 Wetland functions and values
- § 9:48 Functions and values assessment standard
- § 9:49 —Hydrogeomorphic approach
- § 9:50 — —Limitations
- § 9:51 —Alternative methods

VII. CONNECTIVITY OF SURFACE WATERS AND WETLANDS

- § 9:52 Generally

VIII. WETLANDS MITIGATION/RESTORATION

- § 9:53 Wetlands mitigation defined
- § 9:54 Wetlands mitigation types
- § 9:55 —Avoidance
- § 9:56 —Minimization
- § 9:57 —Compensation
- § 9:58 — —On-site mitigation
- § 9:59 — —Off-site mitigation
- § 9:60 Mitigation ratios
- § 9:61 Mitigation banking
- § 9:62 In-lieu fee arrangements
- § 9:63 Wetlands restoration

CHAPTER 10. ENVIRONMENTAL FORENSICS

§ 10:1	Introduction
§ 10:2	Interpretation of aerial photographs
§ 10:3	Underground storage tank corrosion models
§ 10:4	Commercial availability of a chemical
§ 10:5	Petroleum hydrocarbon characterization—Gas chromatography (GC)
§ 10:6	—Proprietary additives
§ 10:7	—Alkyl leads
§ 10:8	—Oxygenates
§ 10:9	—Dyes
§ 10:10	—Weathering
§ 10:11	—Biomarkers
§ 10:12	—Pristane/phytane ratios
§ 10:13	—BTEX ratios
§ 10:14	—BTEX degradation models
§ 10:15	—PIANO analysis
§ 10:16	—Stable isotopes—General
§ 10:17	— —Lead isotopes
§ 10:18	— —Carbon/hydrogen/sulfur isotopes
§ 10:19	— —MTBE isotopic composition
§ 10:20	— —Nitrogen isotopes
§ 10:21	—Source identification of petroleum hydrocarbons via statistical and numerical analysis
§ 10:22	Age dating chlorinated solvents
§ 10:23	—Additives
§ 10:24	—Degradation products and ratios
§ 10:25	—Stable isotope analysis
§ 10:26	Age dating and source identification of perchlorate
§ 10:27	Source identification of dissolved nitrate
§ 10:28	Contaminant transport models
§ 10:29	—Paved surfaces
§ 10:30	— —Liquid transport through paved surfaces
§ 10:31	— —Vapor transport through paved surfaces
§ 10:32	—Transport through soil
§ 10:33	— —Vapor transport
§ 10:34	— —Liquid transport
§ 10:35	— —Challenges to contaminant transport models in soil
§ 10:36	— — —Natural and artificial preferential pathways
§ 10:37	— — —Colloidal transport
§ 10:38	— — —Cosolvent transport
§ 10:39	— — —Model assumptions
§ 10:40	—Groundwater models
§ 10:41	Scanning electronic microscope (SEM)
§ 10:42	Environmental forensic microbiology
§ 10:43	Dendroecology
§ 10:44	Emerging Contaminants—Per- and Polyfluoralkyl Substances (PFAS)
§ 10:45	Conclusion

CHAPTER 11. SCIENTIFIC AND TECHNICAL ASPECTS OF INDUSTRIAL HYGIENE

I. GENERALLY

§ 11:1 Introduction

II. BACKGROUND

§ 11:2 Industrial hygiene—Definition and context

§ 11:3 Industrial hygienists—Definition and certification

§ 11:4 Evolution of the field of industrial hygiene

III. GENERICALLY APPLICABLE INDUSTRIAL HYGIENE CONCEPTS

A. IN GENERAL

§ 11:5 Introduction

§ 11:6 The Hierarchy of controls

B. OCCUPATIONAL EXPOSURE LIMITS

§ 11:7 Published OELs

§ 11:8 Deriving OELs

IV. INDUSTRIAL HYGIENE CONCEPTS RELEVANT TO OSHA HEALTH STANDARDS FOR GENERAL INDUSTRY

§ 11:9 In general

§ 11:10 Ventilation (29 C.F.R. § 1910.94)

§ 11:11 Noise (29 C.F.R. § 1910.95)

§ 11:12 Nonionizing radiation (29 C.F.R. § 1910.97)

§ 11:13 Process Safety Management (PSM) (29 C.F.R. § 1910.119)

§ 11:14 Respiratory protection (29 C.F.R. § 1910.134)

§ 11:15 Confined spaces (29 C.F.R. § 1910.146)

§ 11:16 Toxic and hazardous substances (29 C.F.R. § 1910, Subpt. Z)

§ 11:17 —Adverse health effects and mechanisms

§ 11:18 —Industrial hygiene chemistry

§ 11:19 —Sampling and analysis of air contaminants (29 C.F.R. § 1910.1000 and most other Subpart Z substance-specific-standards)

§ 11:20 —Sampling instruments and methods

§ 11:21 —Analytical instruments and methods

§ 11:22 —Air sampling calculations and comparison of results with standards

§ 11:23 —Asbestos (29 C.F.R. § 1910.1001)

§ 11:24 Ionizing radiation (29 C.F.R. § 1910.1096)

§ 11:25 Hazard communication (29 C.F.R. § 1910.1200)

§ 11:26 Occupational exposure to hazardous chemicals in laboratories (29 C.F.R. § 1910.1450)

§ 11:27 Ergonomics

§ 11:28 Hazard and control banding

V. HISTORICAL ASPECTS OF DISEASES CAUSED BY DUSTS

A. IN GENERAL

- § 11:29 Development of medical knowledge of the roles of certain dusts in diseases

B. EARLY DEVELOPMENT OF INSTRUMENTS AND METHODS FOR THE MEASUREMENT OF DUSTS

- § 11:30 Dust sampling instruments
§ 11:31 Dust measurement efficiency
§ 11:32 Dust sampling collection efficiency
§ 11:33 Methods of analysis
§ 11:34 Particle size and respiratory deposition

C. DUST SAMPLING RESULTS

- § 11:35 Early gravimetric measurements 1910-1920
§ 11:36 Non-asbestos mineral dust—"Dusty Trades" studies (US) 1920-1940
§ 11:37 Asbestos dust measurements 1930-1945

VI. A NOTE ON SELECTED EXAMPLES OF CITATIONS OF HISTORIC LITERATURE AS BEARING ON THE "STATE OF THE ART" IN INDUSTRIAL HYGIENE

- § 11:38 An example from asbestos litigation
§ 11:39 A (tongue in cheek) note in the state of the art of knowledge of the health effects of the practice of law

Table of Laws and Rules

Table of Cases

Index